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ABSTRACT

A method of examining individual variation in responses to Inhelder-Piaget formal reasoning tasks is proposed as a means of identifying cognitive style components of formal reason and as a means of generating more complete descriptions of observable manifestations of formal reasoning. The method is one used by human ethologists and consists of four parts: (1) noninferential observation of both subject and examiner behavior during task administration; (2) formulation of unambiguous, explicit behavioral units to be compiled eventually into a dictionary or ethogram of subject and examiner behavior; (3) observing and recording subject and examiner behavior using lists of behavioral units; and (4) analyzing observational data in order to determine frequencies and sequences of the listed behaviors. Drawing upon some preliminary results obtained by carrying out steps one and two of this method, the authors discuss some observable elements of formal reasoning task responses which seem to be related to cognitive style. They suggest that these and other salient behaviors be observed and recorded carefully for a wide variety of subjects in order to enrich our knowledge of formal reasoning performance and its relationship to factors such as cognitive style. (Author)

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Toward the Identification of Styles of Formal Reasoning

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Over 20 years ago, Inhelder and Piaget wrote in the last chapter of The growth of logical thinking from childhood to adolescence (1958) that few studies in adolescent psychology had focussed on adolescent thinking processes, and the few that were reported did not begin to provide a coherent outline of the whole picture. Of course, Inhelder and Piaget did not end their chapter before providing a bold statement of the way in which their own research outlined an explanation of what they deemed the essential characteristics of adolescent thinking. Although Inhelder and Piaget's model has been criticized justifiably on both theoretical and empirical grounds (see Neimark, 1975; Keating, 1978), it has not yet been adequately reformulated. Using the Inhelder-Piaget tasks, modifications of the tasks, and completely different kinds of measures, researchers continue to look at adolescent and adult behavior in problem solving situations, hoping to find data that will fit the specifications of a reasonably comprehensive, useful theory.

In this paper, we will suggest that one research strategy, non-inferential observation, could prove to be extremely useful in future studies of formal reasoning by providing more explicit, exhaustive descriptions than are presently available of the complex behavior that we are trying to explain.

The observational method to which we will be referring in the present discussion has been used by human ethologists in studies of child behavior in relatively natural settings, for example, in the nursery school (Blurton-Jones, 1972; McGrew, 1972). Within the ethological tradition, observers are careful to avoid attaching any inferential labels to the behavior. One of their goals is to compile a dictionary or ethogram of all units of behavior observed for a certain child or group of children. These units are defined as explicitly and unambiguously as possible. As Reynolds (1976) pointed out, there are problems with defining behavioral units, even when dealing only with non-verbal behavior. For example,

observers may disagree on lumping/splitting decisions or on principles of naming. However, each researcher's units are usually defined so that they can be identified easily in the field and used by other observers in replication studies.

Recently, we attempted to compile a dictionary of verbal and non-verbal behavior of college students as they responded to five of Inhelder and Piaget's formal reasoning tasks. Although the observational setting was hardly natural, we felt that it was not only possible, but also highly worthwhile to use an ethological method to describe what was occurring there. The Piagetian clinical method leaves much room for variation in subject and examiner behavior. One of the criticisms of using the clinical method states that investigators fail to explain how or why they chose certain behaviors out of the pot as critical indices of the subject's level of reasoning (Keating, 1978). Another criticism is that the examiner's procedures, which are seldom described in great detail, vary from study to study such that direct comparison of results across studies is made difficult. The confusion resulting from the failure to specify assessment procedures and response criteria could be cleared up considerably if researchers would specify, by means of behavioral units, precisely what they did during the testing sessions and the context out of which they chose criterion behaviors for rating levels of reasoning. In addition, data could be collected to describe aspects of formal reasoning task performance that have not yet been examined systematically.

Unfortunately, many interesting aspects of task performance cannot be observed directly - e.g., mental calculations or memory searches. However, recent studies have suggested that some non-verbal as well as verbal behaviors that <u>can</u> be observed most likely reveal important features of an individual's approach to problems. For example, Witkin, et al.(1977)

mention several behaviors, including looking at the interviewer's face and leaning toward the interviewer, that were correlated with field dependence in various studies (Ruble & Nakamura, 1972; Konstadt & Forman, 1965; Greene, 1976). Our own observations of responses to formal reasoning tasks suggested that certain behaviors, such as touching the materials or using technical terms in statements, should be observed carefully in order to see whether they occur in consistent patterns for individuals across different tasks. At present, no evidence has been formally assembled to demonstrate the existence of reasoning styles which are defined in terms of observable behaviors. However, research on the field independence-dependence dimension of cognitive style (Witkin, et al., 1977) has provided a framework within which some aspects of formal reasoning task responses can be examined.

Related Cognitive Style Research

The dimension of field independence-dependence, also known as the articulated-global continuum, was first examined using perceptual tasks such as the rod and frame test. As Witkin and others continued to study the dimension, they began to see it as a pervasive feature of a wide range of an individual's activity, including problem solving and interacting with others. Witkin, et al. (1977) have stated that the degree of field independence-dependence is usually consistent for an individual across different tasks and tends to remain stable over time.

Neimark (1977) has contended that the Inhelder-Piaget tasks are measuring field independence in addition to formal reasoning. She notes that the task instructions are often ambiguous and require the subject to extract relevant information about the parameters of the problem himself, which field-independent subjects may tend to do more efficiently. Others, also, have suspected that field independence may be related to formal

reasoning and have looked at subjects' performance on formal reasoning tasks and on measures such as the rod and frame test or embedded figures test. Lawson (1976) found high correlations between scores on the embedded figures test and on two formal reasoning tasks for 25 sixth graders. However, Saarni (1973) found no significant relationship between field independence and formal reasoning for her sample of 64 young adolescents. In fact, she found that the girls who performed at the formal operational level tended to be more field dependent than the less cognitively advanced boys and girls. Saarni interpreted her data as evidence against the claim that the field independence construct can characterize an individual's cognitive functioning across many tasks, including those involving multi-step problem solving.

Searching for Style Components in Formal Reasoning Task Performance

In both the Saarni and Lawson studies cited above, the investigators used separate tasks to measure the two aspects of cognitive performance. Another way to assess the extent to which field independence is required in formal reasoning tasks would be to examine in detail the formal reasoning tasks themselves. As Martorano (1977) noted, formal reasoning tasks vary significantly in degree of structure, depending on the type of instructions given. Questions such as the following could be asked in order to determine the degree of ambiguity in task instructions: When presenting the task, did the examiner describe the apparatus, name the different variables involved in the problem, or define terms? Did he ask a series of specific questions as the subject worked or did he remain silent until the subject stated his conclusion? Did the subject ask questions about what he or she was supposed to do?

Another strategy would be to look for evidence of field independence-dependence in the subject's behavior patterns. According to Witkin's

theory and related findings (Ruble & Nakamura, 1972; Konstadt & Forman, 1965), field dependent individuals tend to look more often at the faces of others, because of their apparent tendency to rely heavily on information from the social context in defining their attitudes. Greene (1976) found that when comparing subjects' non-verbal behavior at 2 feet and at 5 feet from an interviewer, field-dependent persons showed an increase in behaviors such as mouth touching and forward leaning at the greater distance while field-independent persons showed "distancing" behaviors (arm crossing, leg crossing, and absence of forward leaning) at both 2 feet and 5 feet. The non-verbal behaviors mentioned in these studies have not been examined extensively and may not be valid or reliable indicators of field independence-dependence. However, if we observe and record them along with other behaviors during formal reasoning assessment sessions and find that these non-verbal behaviors occur frequently or in a consistent order in response sequences for certain individuals across tasks, we may have some evidence for a cognitive style dimension in formal reasoning task responses.

As soon as we begin to look for consistency in a subject's behavior across different tasks, it becomes necessary to analyze the tasks to determine their similarities and differences in content and mode of presentation. Because the tasks used to measure formal reasoning vary from study to study, we will describe briefly the five tasks used in our study before discussing the use of behavioral units in task analysis.

Ethogram Construction for Formal Reasoning Tasks

The five tasks administered in our study were the magnetization task, the pendulum task, the horizontal plane task, the balance task, and the correlations task, adapted from Inhelder and Piaget (1958). According to our procedure, the first three tasks were relatively unstructured, while the balance and correlations tasks were presented in the form of a series of

questions about specific arrangements of materials as determined by the examiner. For each of the first three tasks, the subject was expected to state a hypothesis to predict or explain the actions of parts of the task apparatus, manipulate the materials to prove the hypothesis, and state a conclusion. The examiner's task was to describe the apparatus, explain what was required of the subject, and respond to or simply observe the subject's actions as he or she worked. In the balance and correlations tasks, the examiner described the materials, but then asked the subject questions which demanded numerical answers and explanations of the procedures by which the answers were obtained.

Of course, each separate task elicited some behaviors which were unique to that task. By observing and recording examiner and subject behavior, we collected narrative descriptions of 34 testing sessions. From these descriptions, we formulated lists of units of both the subject and the examiner behavior that we observed for each task.[1]

Some of the units of subject behavior defined types of actions or statements which were used to rate the subject's level of reasoning. For example, a unit called Say(conclusion), defined as "Name factor(s) and say that the factor(s) changed the rate of oscillation," was one of the criterion behaviors for the pendulum task. In order to be scored IIIB on that task, a subject's behavioral repetoire had to include a statement that the length of string, only, changed the rate of oscillation. For some tasks, especially the magnetization task, the subjects displayed many variations in method of proof and in other key responses, making it necessary to add more and more units to the lists. Most certainly, our lists of examiner and subject behavioral units do not reveal all the variety and subtlety of the responses

[1]Lists of task-specific examiner and subject behavior are available from the authors.

used for rating operational levels. However, if researchers continue to refine and amend the lists, we should be able to report the elements of formal reasoning responses with greater and greater precision.

In addition to specifying criterion behaviors for particular tasks, the behavioral units can specify verbal and non-verbal behaviors which tend to occur for all of the formal reasoning tasks. We compiled lists of examiner and subject behaviors which are defined without reference to any of the tasks, so that their frequency and sequence of occurrence can be recorded for an individual across the different tasks. (See Appendix for lists of subject and examiner behaviors.)

The purpose of formulating units of examiner behavior was to provide a means for recording variations in the examiner's initial presentation of the task and for noting elements of the examiner-subject interaction. The units of subject behaviors were chosen from a combination of sources and for several purposes. Many of the non-verbal units were selected from a list that Grant (1968) compiled of common behaviors exhibited in interviews. Because Grant's units corresponded to behaviors that we observed in our study, we included his definitions in our list. Most all of the other units were constructed from the protocol data we collected, with the exception of three verbal units, which were formulated from protocols in Newell and Simon (1972).

Many of the verbal and non-verbal units of subject behavior were chosen with an outline of a typical task sequence in mind and with the idea that eventually, over many observations, certain units may tend to occur within certain "stages" in a task response sequence. Piaget (1972) described briefly a typical sequence in a formal operational response as follows:

1. Run a few trial and error experiments.
2. Stop experimenting and begin to list possible hypotheses.
3. Test hypotheses, trying to dissociate the factors involved and

study one factor at a time.

He contrasts that with a typical concrete operational sequence:

1. Act directly on materials by trial and error without dissociating the factors involved.
2. Try to classify or order what happened by looking at the results of co-variations.

A more general type of sequence within which subjects could vary is the following, as adapted from Omark (1976):

1. Comprehending the problem - includes "defining the parameters of the task" (Pitt, 1976).
2. Working through the problem.
3. Presenting the conclusion.

If such a sequence could describe subjects' responses comprehensively, behavioral units could be used to specify what constitutes each step in the problem-solving sequence, and ways in which subjects differ within each step.

The units could also be used to explore ways in which the tasks may relate to an individual's past and present life experience. For instance, the unit, Say (technical terms) could identify ways in which a subject is using accumulated knowledge of the task content in his or her response. Say (affect) could indicate a subject's interest in the task. One could record the number of questions asked by the subject or the number of comments offered spontaneously as an indication of level of articulateness, a dimension which deGroot (1965) found interesting in his study of chess-playing strategies.

Present Research on Styles of Formal Reasoning

The authors of this paper have tested over 400 subjects with the use of formal reasoning tasks. They have both been struck by the substantial variation among the responses assessed at the same Inhelder-Piaget developmental

level (e.g., II-A or III-B). For example, some subjects assessed at the consolidated level of formal operations (III-B level) for the equilibrium in the balance task will touch and physically investigate the balance device with its weights at the initial phase of the task administration and then subsequently will not touch the device but merely look at the balance device for the remaining period of the task administration as the examiner poses balance problems to the subject. Other III-B subjects for the same task will not initially engage the balance device physically, but will work with the balance device when questions are asked by the examiner which are not readily answered by the subject. With those subjects, physical interaction with the balance device when specific problems are posed seems to facilitate understanding of the law of the lever.

Our evidence for the existence of different styles of formal and concrete reasoning that remain consistent for individuals across tasks is primarily anecdotal at this point. However, the laborious procedure which the authors are following to identify such styles may prove to be fruitful. To reiterate, in an initial phase of inquiry, the responses of 34 subjects to five Inhelder-Piaget tasks were observed to identify behaviors which occur as subjects respond to those tasks. Those behaviors were organized in lists, as an ethologist would organize behaviors of rhesus monkeys in threes to provide an ethogram of arboreal behavior among rhesus monkeys (Reynolds, 1976). The next phase of this inquiry is to record a host of responses to formal reasoning tasks and then to use the constructed behavior lists to locate prominent sequences of behaviors among the task responses which could be used as candidates for describing distinctive styles of formal and concrete reasoning. To facilitate that phase, one of the authors is presently conducting a study of formal reasoning among urban adolescents in Chicago in which he is testing 240 subjects with six Inhelder-Piaget tasks. There are 20 subjects from each of 12 sample cells determined by the

cross-classification of three factors: sex (male and female), socio-economic class (lower and middle SES), and age (14, 16, and 18 years of age). Five subjects from each of those 12 groups of 20 subjects are being videotaped and their task responses will be carefully and laboriously analyzed with the use of the lists of behavioral units. The subjects being videotaped constitute a racially and ethnically heterogeneous sample of adolescents and thus substantial variation among the task responses assessed at each of the reasoning levels for the tasks is expected. In this effort, we are going back to one of the first steps in scientific research - i.e., detailed non-inferential observation. We hope that the emerging descriptions of formal operations in action will not only generate new hypotheses, but also fill in the present black-and-white sketches of formal operations with needed color, texture, and detail.

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Appendix

Examiner Behaviors

Non-verbal

Point to - Point to materials.

Touch (materials) - Place fingers on materials.

Manipulate (materials) - Push, pull, lift, or arrange materials.

Look (materials) - Look at materials.

Look at - Look at subject.

Gesture - Make hand and arm movements while speaking.

Verbal

Ask (task question) - Ask question as pre-determined for all subjects for each specific task.

State (problem) - Tell subject what is required to complete the task.

State (rules) - Tell subject what he/she may and may not do.

Identify (elements) - Name certain elements or parameters of the problem and say that they are important.

Describe (apparatus) - Describe features of task materials.

Define (terms) - Define certain terms that relate to the problem.

Note (results) - Note to the subject an aspect of the results of a manipulation of the task materials.

Suggest (guess) - Tell subject to try to guess the conclusion.

Suggest (experiment) - Tell subject to go ahead and try experimenting with the materials.

Suggest (repeat) - Tell subject to try the experiment or calculation again.

Ask (thoughts) - Ask subject to say what he/she is thinking.

Ask (ongoing actions) - Ask subject what he/she is doing.

Ask (results) - Ask a specific question about the observed results of a manipulation of the task materials.

Ask (factor) - Ask subject what role (if any) a factor plays in the problem.

Ask (conclusion) - Ask subject to state conclusion.

Ask (certainty) - Ask subject to tell how certain he/she is that his/her answer is correct.

Examiner Behaviors

Verbal

Ask (procedure) - Ask subject how he/she arrived at answer.

Ask (rationale) - Ask subject why he/she chose a certain answer.

Subject Behaviors

Non-verbal

Look at - Look at examiner's face.

Look up - Look suddenly up in the air, then slowly look down. (Brannigan& Humphries, 1972)

Look down - Look down at feet, lap, or floor. *

Look around - Look around room, to side,out window.

Scan (materials) - Move eyes quickly over materials, focussing on different parts for a second or less.

Stare (materials) - Focus eyes on a part of the materials for at least five seconds.

Smile - Draw lip corners up and back. *

Frown - Draw eyebrows together and lower them at center. *

Bite lip - Draw one lip, usually the lower, into mouth and hold between teeth.*

Laugh - Make sounds of laughter. *

Sigh - Inhale and exhale, making a noise. *

Nod - Make normal affirmative gesture by moving head up and down. *

Shake - Make normal negative gesture by shaking head from side to side.*

Shrug - Raise and lower shoulders. *

Gesture - Make hand and arm movements while speaking. *

Fold arms - Fold arms across chest. *

Touch (materials) - Place fingers on apparatus or materials. Includes manipulating materials, but not as part of an experiment.

*(Grant, 1968)

Non-verbal

Displacement activities - Groom head, scratch, fumble, tap.

Lean (examiner) - Lean forward from the hips toward the examiner.

Lean (task) - Lean forward toward the task materials.

Settle - Make adjusting movement into a different posture in chair. (Grant, 1968)

Verbal

Ask (problem) - Ask examiner to re-state the problem.

Ask (definition) - Ask examiner to explain what a term means.

Ask (materials) - Ask a question about the nature of the materials.

Ask (feedback) - Ask examiner to comment on one's answer. For example, "Is this right?"

Agree - Say "O.K.," "Uh huh," "All right," "Yes,", etc. in response to a comment or question by the examiner.

Describe (materials) - Describe features of task materials.

Say (attempting) - Say what one is trying to do at the moment. *

Say (problem type) - Say that one recognizes the problem as a certain type.

Say (task) - Say what one thinks is necessary to solve the problem or complete the task. For example, "I have to do ___,___ and____." *

Say (next step) - Say what one plans to do next. *

Note (results) - Describe the results of an experiment or simple uncontrolled manipulation of the materials.

Say (affect) - Say explicitly that task is enjoyable or not enjoyable.

Say (degree of difficulty) - Say explicitly that the task is difficult or easy.

Say (familiarity) - Say explicitly that the task is familiar or strange.

Say (don't know) - Say "I don't know" in response to examiner's question.

Say (guess) - Say that an answer or conclusion was chosen as a guess.

*formulated after reading through written protocols in Newell & Simon, 1972.

Subject Behaviors

Verbal

Say (technical term) - Say term from science or mathematics which relates to task materials or principles underlying the problem.

Say (state description) - Name principles, propositions , facts which relate to solving the problem. *

Say (process description) - Describe one's procedure for solving the problem.*

Say(certainty) - Say explicitly that one is sure or not sure that one's answer or conclusion is correct, complete.

Locate mistake - Say that one made a mistake in a certain place in the problem solving sequence.

Change answer - Say "No!" "Wait!" or "Oh!" and then say an answer that contradicts what one said previously.

*The distinction between state and process descriptions is taken from Simon (1969).